# NORTH DAKOTA DEPARTMENT OF HEALTH
## Environmental Health Section

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December 10, 2002

Mr. Kevin Golden
Air and Radiation Program
U.S. EPA - Region VIII
One Denver Place
999 - 18TH Street, Suite 300
Denver, CO 80202-2466

Dear Kevin:

As requested, enclosed are copies of the responses (2) to Basin Electric summarizing North Dakota Department of Health (NDDH) review of the ENSR MM5 Calpuff modeling analysis. This analysis was submitted by ENSR on behalf of Basin Electric at the May 2002 Hearing.

It is our understanding that ENSR proposes to rerun the analysis after addressing the deficiencies noted in the NDDH letters.

Sincerely,

Steven F. Weber
Modeling Coordinator
Division of Air Quality

SW:csc
Enc:

MEMO TO : Interested Parties

FROM : Steven F. Weber, Manager
Air Quality Impact
Division of Air Quality

RE : Sensitivity Testing of Calpuff/Calmet
Grid Resolution

DATE : September 26, 2002

The Calpuff/Calmet modeling system was tested to determine the sensitivity of Calpuff output to changes in the grid configuration. Testing was conducted for grid cell sizes of 10 km, 5 km and 3 km, and for 8 vs. 12 vertical layers. To bridge the process from lowest to highest resolution, testing was conducted specifically for the following four grid configurations:

1) 10 x 8 (10 km grid cell size and 8 vertical layers)
2) 5 x 8 (5 km grid cell size and 8 vertical layers)
3) 5 x 12 (5 km grid cell size and 12 vertical layers)
4) 3 x 12 (3 km grid cell size and 12 vertical layers)

The 10 x 8 grid reflects the configuration currently utilized by NDDH, while the 3 x 12 grid is consistent with Basin Electric's (ENSR's) proposal.

To expedite the testing process, the source inventory was limited to large, increment-consuming sources only (i.e., oil and gas were not modeled). Thus, sensitivity results are useful in a relative sense, but do not reflect true increment consumption. The source inventory (increment-consuming emissions only) included:

Antelope Valley Station
Coal Creek Station
Colstrip Station
CELP Boiler
Coyote Station
Grasslands Gas Plant
Leland Olds Station
Milton R. Young Station
Stanton Station

The single Year 2000 meteorological data, as previously developed by the North Dakota Department of Health (NDDH) was utilized in the sensitivity testing. Testing did not include MM4/MM5 data. Calpuff/Calmet technical settings were similar to those previously used and documented by NDDH. Layer-dependent bias (surface vs. upper air) for 12 layer tests was parameterized as closely as possible to settings for 8 layer tests. Receptor locations were equivalent to Class I area receptors previously used by NDDH.

Results of the sensitivity study are provided in the attached table. High, second high predictions (no receptor averaging) are provided for each grid configuration. Sensitivity results indicate very little difference in predictions for the four configurations tested.

Future sensitivity testing by NDDH will consider the impact of addition of MM4/MM5 meteorological data.

SFW:saj

Calpuff/Calmet Sensitivity Testing -
Calpuff Output ($\mu g/m^3$) Using 10 km, 5 km,
3 km Grid Size and 8 vs. 12 Vertical Layers

| | T.R. South | T.R. North | T.R. Elkhorn | Lostwood | Overall |
|---|---|---|---|---|---|
| 3-hr HSH | | | | | |
| 10 x 8 grid* | 18.3 | 16.7 | 22.4 | 22.4 | 22.4 |
| 5 x 8 grid* | 18.7 | 17.4 | 22.3 | 23.1 | 23.1 |
| 5 x 12 grid* | 19.1 | 15.4 | 22.5 | 21.1 | 22.5 |
| 3 x 12 grid* | 19.4 | 15.7 | 22.7 | 22.0 | 22.7 |
| 24-hr HSH | | | | | |
| 10 x 8 grid* | 6.1 | 5.3 | 5.9 | 5.1 | 6.1 |
| 5 x 8 grid* | 6.2 | 5.3 | 6.0 | 5.1 | 6.2 |
| 5 x 12 grid* | 6.5 | 5.4 | 6.2 | 5.2 | 6.5 |
| 3 x 12 grid* | 6.5 | 5.7 | 6.1 | 5.3 | 6.5 |

* The first number represents grid cell size and the second number is vertical layers. For example, the 10 x 8 grid uses grid cell size of 10 km and 8 vertical layers.

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November 25, 2002

Ms. Deb Levchek
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503-0564

Re: North Dakota Department of Health
Review of Calpuff MM5 Air Quality
Modeling Analysis (see also Department
of Health letter of October 30, 2002)

Dear Ms. Levchek:

The North Dakota Department of Health (NDDH) has completed it's review of the information regarding ENSR Corporation's Calpuff MM5 modeling which was submitted on August 16, 2002. To expand on the comments contained in the October 30, 2002 letter (addressing NDDH preliminary review), the latest review produced the following additional comments and observations:

1) The NDDH can find no evidence that the impact of cloud cover was accounted for in the ENSR Calpuff analysis. That is, clear sky conditions were assumed for each hour of the year-long model run at each station. Specifically, the sky cover fraction was set to zero for all hours for all gridded locations in the CLOUD.DAT files (provided by ENSR), and sky cover was zero for all hours for all stations in the SURF.DAT files (provided by ENSR). In addition, cloud ceiling height was held to a constant 4500 feet (for all hours and stations) in the SURF.DAT files.

   The omission of appropriate cloud cover data is problematic and will have a profound effect on Calmet/Calpuff results. Calmet uses cloud cover fraction to calculate both mixing height and stability regime, both of which have a strong effect on dispersion and resulting concentrations.

2) The NDDH notes that the Calpuff source input coordinates (locations) for several oil and gas wells in the vicinity of the Lostwood Wilderness Area were adjusted southward (as much as 14 km) by ENSR in order to fit within the ENSR Calmet/Calpuff grid. This displacement of source locations is

not appropriate. As indicated in our October 30, 2000 letter, the northward extent of the ENSR domain should be extended so that these adjustments to source locations are unnecessary.

3) The "current" source inventory used to develop the scenario results documented in Table 6-5 of the ENSR May 24, 2002 report appears to exclude several fixed-emission sources. Excluded sources are:

Heskett Station
DGC (fixed-emission stacks)
Mandan Refinery
Lignite Gas Plant
Tioga Gas Plant

Because these sources were <u>included</u> in the "baseline" component of the modeling, net increment consumption, as documented in Table 6-5, would be understated.

4) Section 2.1 of the ENSR Report suggests that "NDDH and EPA persisted (copied) the land use characteristics in North Dakota to Canada in their analysis." This is not correct. For both March 2002 and April 2002 Class I analyses, the NDDH utilized terrain and land-use data sets which extended well into Canada.

If you have any questions on these comments, please contact Rob White or myself.

The above comments have been relayed to Bob Paine of ENSR Corporation in recent telephone discussions. It is our understanding that ENSR proposes to rerun the Calpuff MM5 2000 analysis with corrections addressing the input deficiencies noted above, and in our October 30, 2002 letter. The NDDH may be able to provide materials to assist in, and shorten, this effort.

A meeting is planned for 9:00 a.m. December 3, 2002 at the Missouri Office Building to discuss the ENSR MM5 Calpuff analysis.

Sincerely,

Steven F. Weber
Modeling Coordinator
Division of Air Quality

SW:csc

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October 30, 2002

Ms. Deborah Levchek
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503-0564

Re: North Dakota Department of Health Review
of Calpuff MM5 Air Quality Modeling Analysis

Dear Ms. Levchek:

The North Dakota Department of Health (NDDH) has reviewed the information regarding Calpuff MM5 modeling which was submitted on August 16, 2002. The air quality modeling analysis was prepared on behalf of Basin Electric Power Cooperative by ENSR Corporation. Upon preliminary review of the materials submitted, the NDDH has the following comments and observations:

1) Class I area increment consumption predicted by ENSR using their Calpuff MM5 methodology is 50 to 75 percent lower than results obtained by NDDH. Such a great difference in predictions would not be expected from changes in grid resolution or source of meteorological data (MM5), which are the two primary differences between the ENSR and NDDH methodologies. The NDDH recently completed sensitivity testing to determine the utility of increasing horizontal and vertical resolution in the Calmet/Calpuff grid. Testing considered grid cell sizes of 10 km, 5 km, and 3 km, and 8 versus 12 vertical layers. Testing included the specific configurations used by NDDH (10 km cell size, 8 layers) and ENSR (3 km cell size, 12 layers). The testing process is described in the attached memorandum. Basically, the NDDH found very little difference in Class I area predictions among the grid configurations tested.

   The NDDH intends to also conduct sensitivity testing of impact from the addition of MM4/MM5 meteorological data.

2) There appears to be a bias toward overstatement of wind speeds in the MM5 data set used by ENSR, which may have contributed to their very low predicted concentrations. To this point, the NDDH has closely examined winds associated with two of the

two-week periods of meteorological data processed by ENSR. These episodes were selected to include a winter period (January 1-15), and a summer period (July 1-15) which contained two of the higher 24-hour predictions obtained by NDDH. The NDDH used the EnviroModeling CalDesk Software to visualize output wind fields from Calmet. For comparison, the NDDH ran Calmet for the same two periods using its own input data, but with the grid resolution modified to match that of ENSR's.

Upon review of these two-week periods, the NDDH noted a tendency for the Calmet winds generated by ENSR to be consistently and significantly stronger than those found in the NDDH Calmet output. Further, the NDDH wind field consistently agreed very well with the raw (NWS) observations at Glasgow and Bismarck. Also, the NDDH found the overstatement of wind speed in the ENSR data to be greater during low wind conditions and at lower levels. The ENSR data appeared particularly overstated during stagnant conditions. NDDH wind directions also compared more favorably with observations than ENSR wind directions.

Two examples of the difference in ENSR and NDDH Calmet wind fields are provided in attached Exhibits 1 and 2. These exhibits reflect Calmet wind fields for a day (July 2, 2000) where NDDH found relatively high 24-hour predicted concentrations at Class I receptors. As shown, the ENSR wind speeds (Exhibits 1a, 2a) are several multiples of (i.e., much higher than) the NDDH speeds (Exhibits 1b, 2b), particularly in the zone of primary transport between major sources and T.R. National Park. Moreover, the NDDH wind fields are much more representative of the observed (Calmet layer averaged) winds at Glasgow and Bismarck.

During the four weeks of data inspected, the NDDH found cases where the NDDH hourly wind speeds exceeded ENSR's in a portion of the grid. But these cases were rare and, on balance, the ENSR winds were significantly stronger. For a more comprehensive assessment of the difference in NDDH and ENSR wind speeds, the NDDH analyzed sounding-hour (i.e., 00Z and 12Z) wind speeds for the entire January episode and the entire July episode. The analysis compared observed winds (NWS) at Glasgow and Bismarck with NDDH/ENSR Calmet generated winds for the two grid cells which contain the NWS stations. For each episode, sounding-hour wind speed was accumulated at these grid cells, then averaged for the episode. The ratio of average Calmet wind speed to average observed wind speed was then determined. The observed wind speed reflects the

stations' layer-average as obtained from Calmet, using NWS sounding data as upper-air station input.

Results of the wind speed analysis are provided in Exhibit 3 for the January episode and in Exhibit 4 for the July episode. In general, Exhibits 3 and 4 show the Calmet wind speeds generated by ENSR are consistently and substantially higher than observed (i.e. ratios much greater than 1.0). Differences are greatest for the July episode, which contained some of the higher Class I area $SO_2$ predicted concentrations found by NDDH. Differences are also greater in lower layers, where primary transport would be expected to occur.

To summarize wind field comparisons, it appears that the ENSR Calmet wind speeds overstate observations. The higher ENSR winds will likely result in increased dilution and lower Class I area predicted concentrations. Moreover, the increased wind speed may also increase mixing height, thus enhancing the underprediction effect. (The NDDH found some visual evidence of increased ENSR mixing heights during the CalDesk review of the two episodes).

3) There appears to be an error in the land use parameterization employed by ENSR. As seen in Exhibit 5, most of the area of Fort Peck Reservation is coded as a water body. This is not correct, as Fort Peck Reservation is primarily agricultural and rangeland. This error will certainly have a significant effect on predictions at Fort Peck and Medicine Lake receptors. The impact on other Class I area receptors is less certain.

The effect of the land use coding error is demonstrated in Exhibit 6, where a very peculiar mixing height field results.

4) The NDDH considers the northward extent of the ENSR computational domain inadequate for predictions at Lostwood Wilderness Area and Fort Peck Reservation. IWAQM guidance suggests the Calmet horizontal domain should extend 50 km beyond outer receptors and sources. This buffer is needed for proper simulation of return flow conditions.

5) ENSR indicated the NDDH precipitation data file was used in their Calmet execution. Because the ENSR base time zone was C.S.T. and the NDDH base time zone was M.S.T., precipitation data would have been one hour off (if not corrected) in ENSR's Calmet execution.

6) Calmet technical options utilized by ENSR were not consistent with IWAQM (and other) recommendations. For example, the O'Brien procedure was deployed for ENSR's analysis, while IWAQM (and Earth Tech) recommends no deployment. Number of passes in smoothing (NSMTH) was set to 2 at layers 2 and higher, while IWAQM recommends 4. Also, the use of MM5 pseudo-stations for observations is not consistent with informal guidance. (EPA/State August 2002 modeling workshop - concluded MM5 should only be used as initial guess field. Also, Earth Tech, in Calmet User's Guide, recommends always using actual observational data, regardless of method of MM5 incorporation). Without incorporating actual observations, there is no guarantee the model winds will match observations at stations (as was the case for the ENSR data noted in Comment #2).

7) In Table 6-3, the 24-hour MAAL (41.85 $\mu g/m^3$) and the 3-hour MAAL (187.81 $\mu g/m^3$) for TRNP North Unit appear questionable because they are so much larger than the values for other TRNP units.

8) In Tables 6-4 and 6-5, predictions for other Class I areas seem unreasonably low when compared to predictions for Fort Peck Reservation. (Table 6-4, highest overall 3-hour prediction occurred at Fort Peck?)

9) The NDDH also has concerns with some aspects of the Calpuff performance evaluation conducted by ENSR. First, some large Canadian sources were shifted several ten's of kilometers south to fit within ENSR's computational grid. Second, the background value used by ENSR (4 $\mu g/m^3$) is much too large. Two principles govern the background used in a performance evaluation:

- it must be unbiased by any of the sources explicitly modeled,
- it must be a long-term average (i.e., equal probability that the actual background on a given day is higher or lower than the value assumed).

The background value used by ENSR is nearly twice as high as the Year 2000 annual average observed at TRNP South Unit monitoring site (2.1 $\mu g/m^3$). Because less than minimum detectable values are observed at TRNP South more than two-thirds of the year (Year 2000), a background reflective of half the minimum detectable (i.e., 1.3 $\mu g/m^3$) would be more representative of a long-term, unbiased background, although the NDDH regards background for this context as negligible.

The concern with the above aspects of ENSR's performance evaluation is that they will serve to artificially inflate the magnitude of the modeling results relative to observations, and thus help justify adjustment of Calmet/Calpuff technical inputs in order to lower predictions.

In summary, it appears that wind speeds in the ENSR analysis are overestimated relative to observations, and that this overestimate is more pronounced during episodes of low wind speed conditions, when highest predictions generally occur. The higher winds would also increase the calculated mixing height, thus possibly enhancing the underprediction effect.

At this time, the NDDH will not speculate on the cause of the wind speed bias evident in the ENSR data. But the NDDH would be willing to work with Basin Electric and ENSR to resolve the wind speed bias and other input anomalies noted above.

If you have any questions, please contact Rob White or myself.

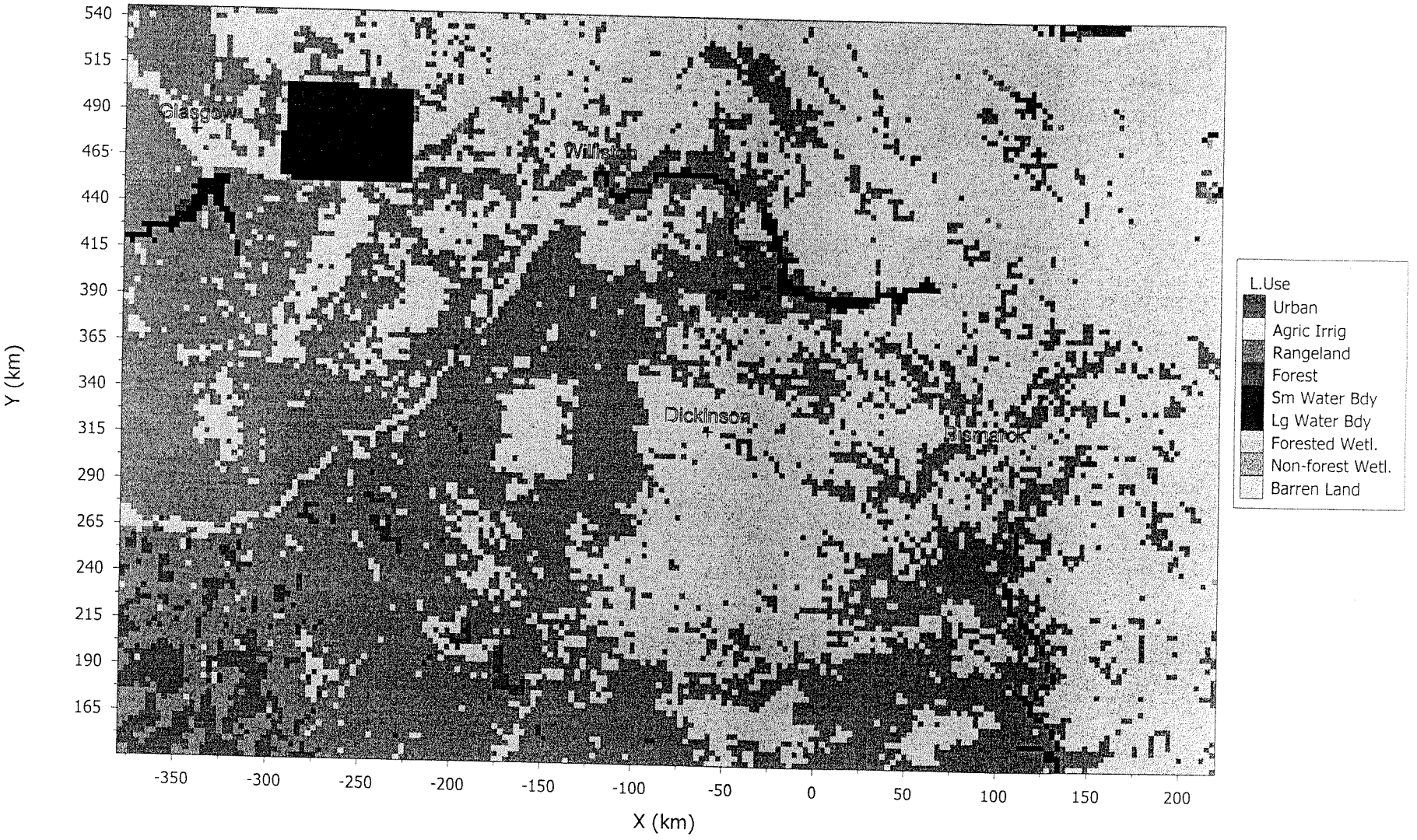
Sincerely,

Steven Weber

Steven F. Weber
Modeling Coordinator
Division of Air Quality

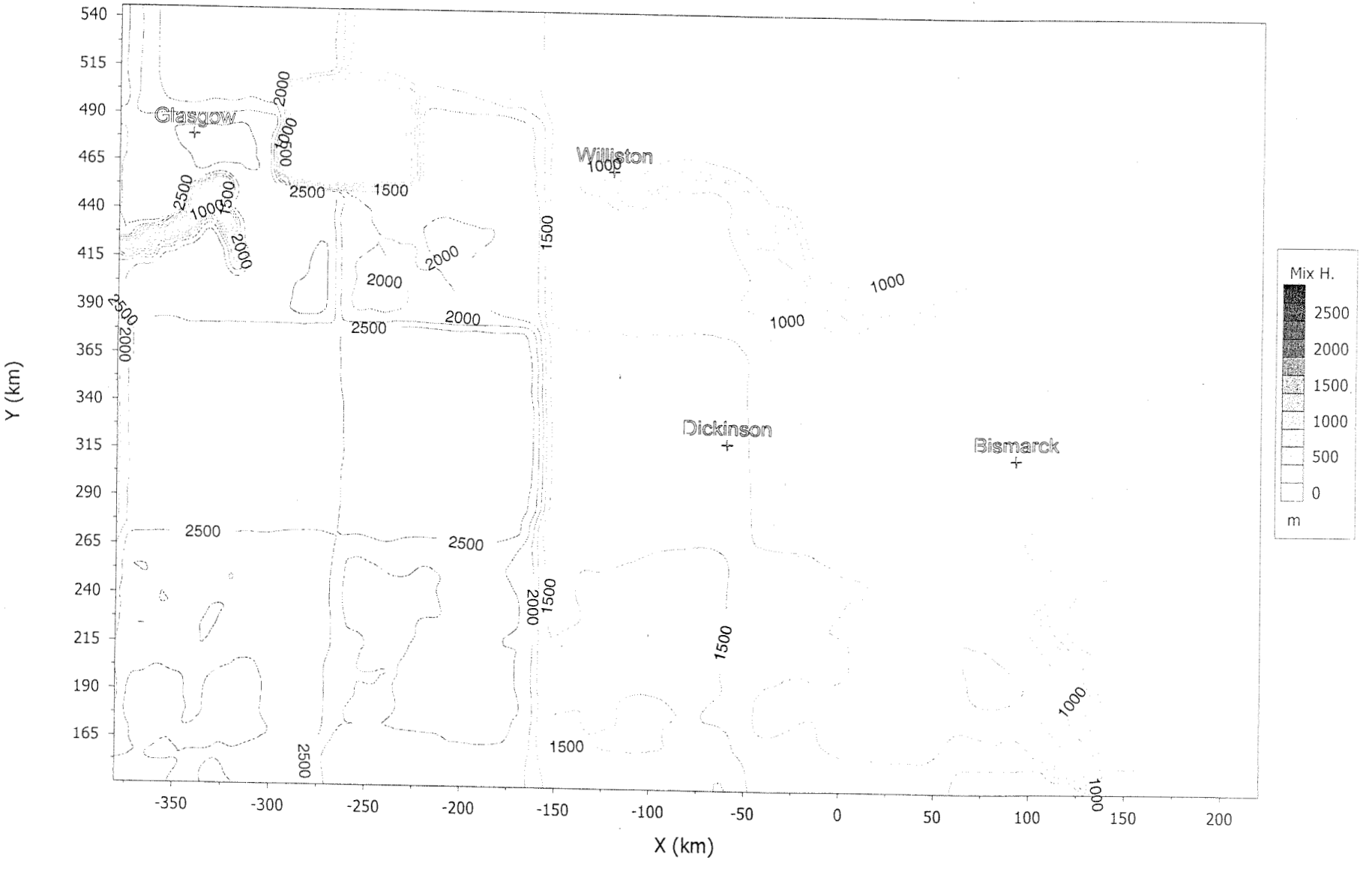
SW:csc

ENSR Land Use



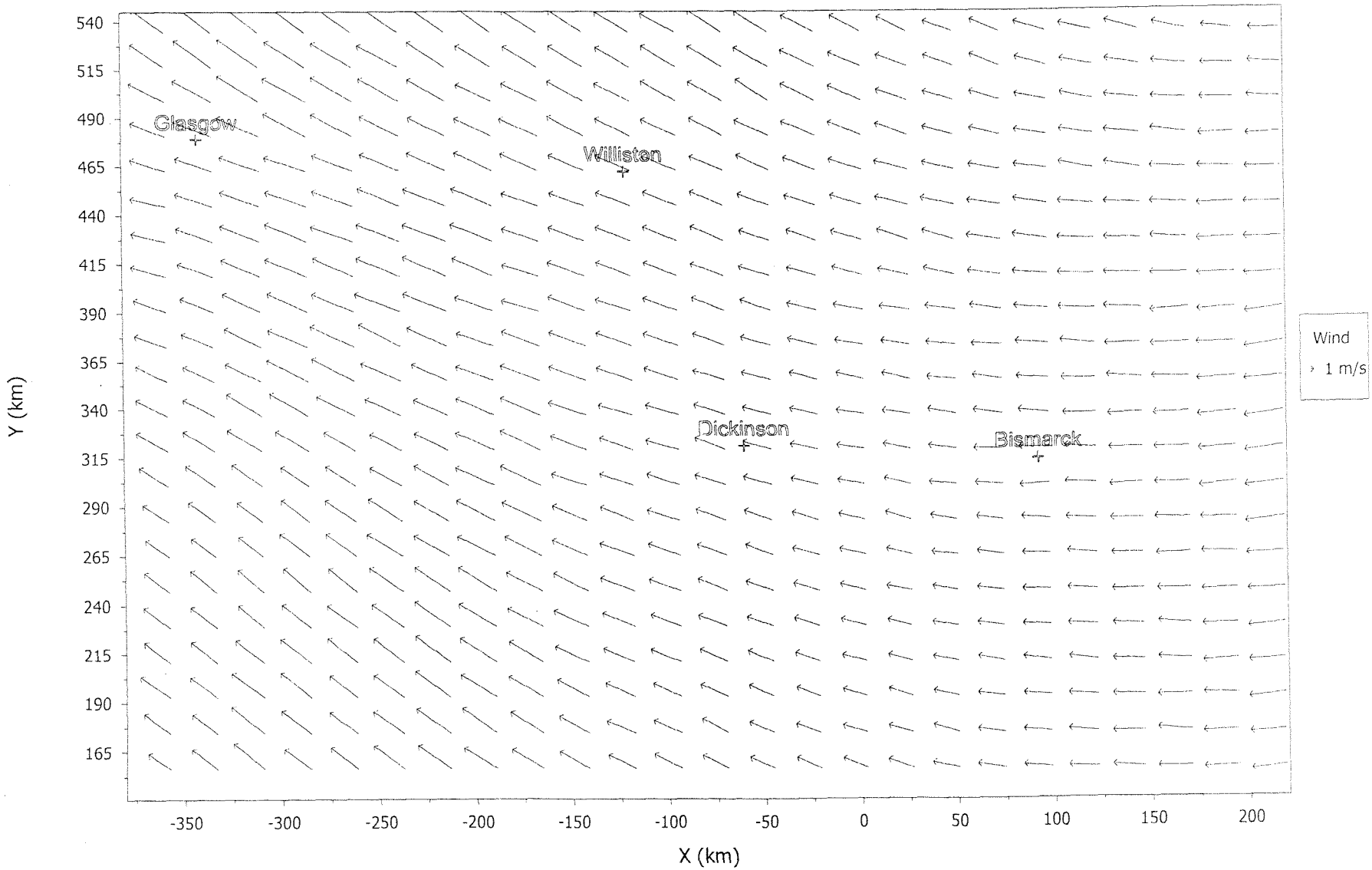
# Exhibit 6

ENSR Mix. Ht. - 07/02/00 Hour 14 CST



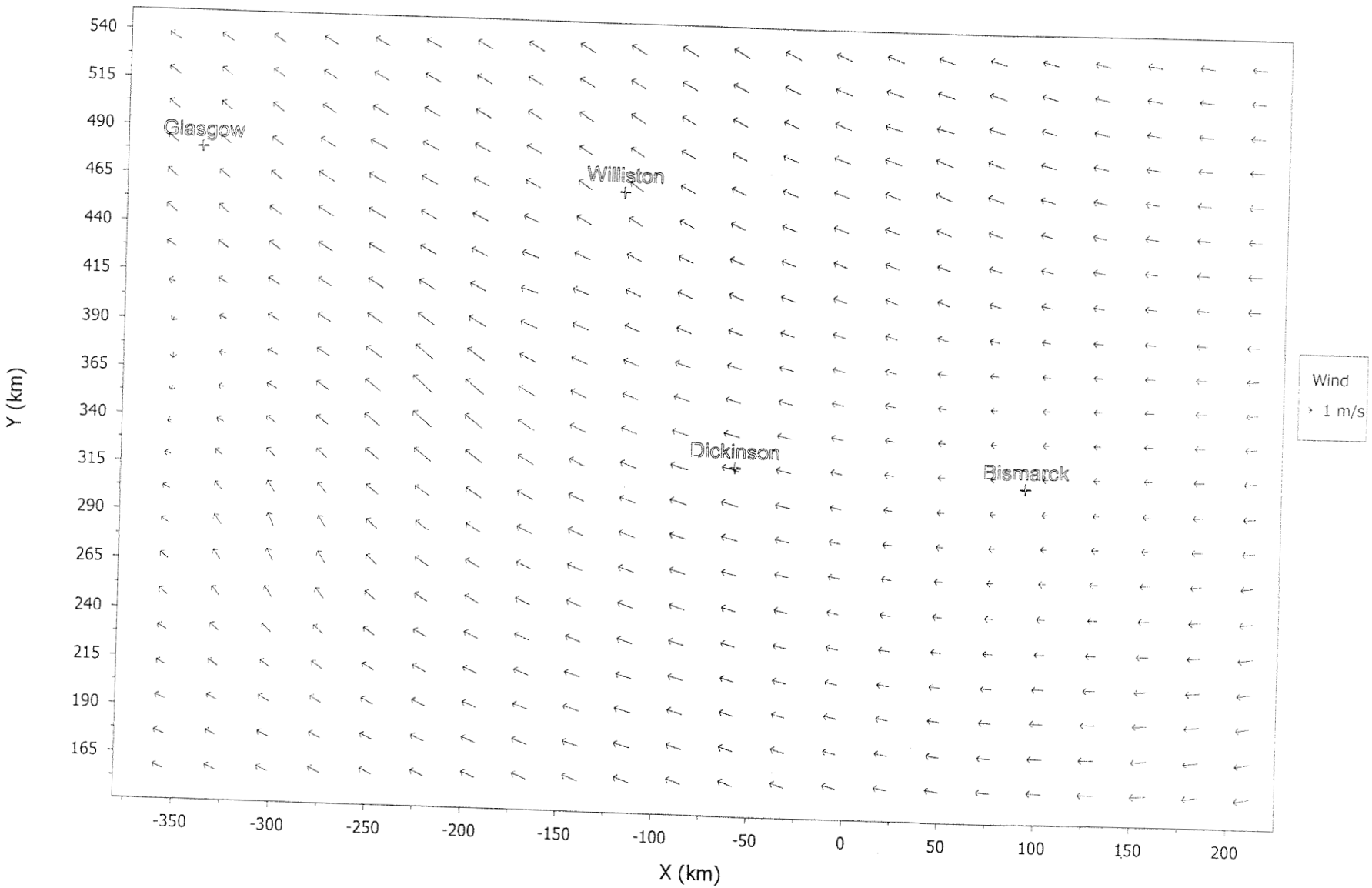
# Exhibit 1a

ENSR - 07/02/00 Hour 21 CST
Z Level = 330 Meters
Observed Bismarck WS = 1.7 m/s
Observed Glasgow WS = 3.7 m/s



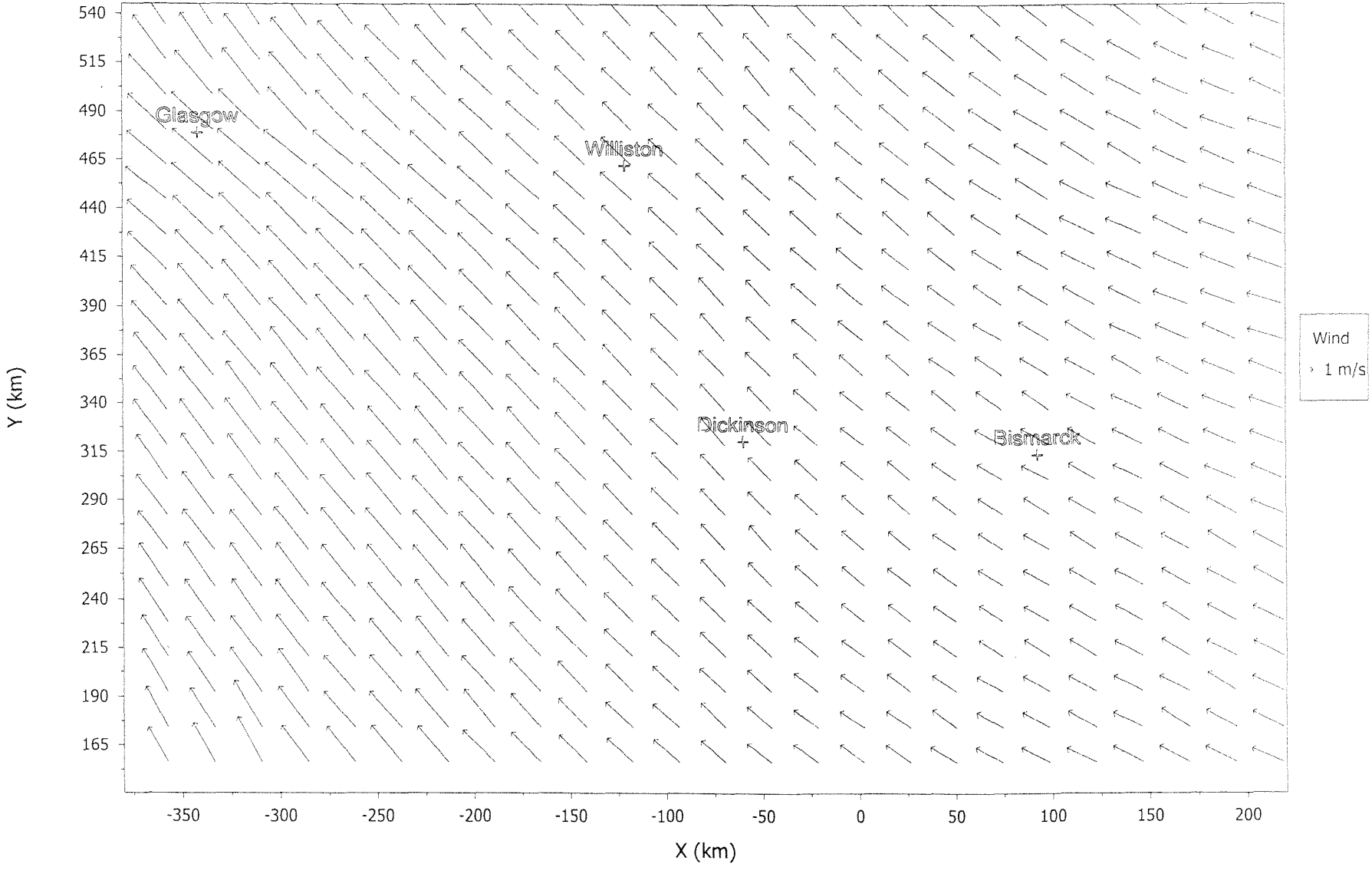
# Exhibit 1b

NDDH - 07/02/00 Hour 21 CST
Z Level = 330 Meters
Observed Bismarck WS = 1.7 m/s
Observed Glasgow WS = 3.7 m/s



# Exhibit 2a

ENSR - 07/02/00 Hour 23 CST
Z Level = 500 Meters
Observed Bismarck WS = 2.1 m/s
Observed Glasgow WS = 3.9 m/s



# Exhibit 2b

NDDH - 07/02/00 Hour 23 CST
Z Level = 500 Meters
Observed Bismarck WS = 2.1 m/s
Observed Glasgow WS = 3.9 m/s

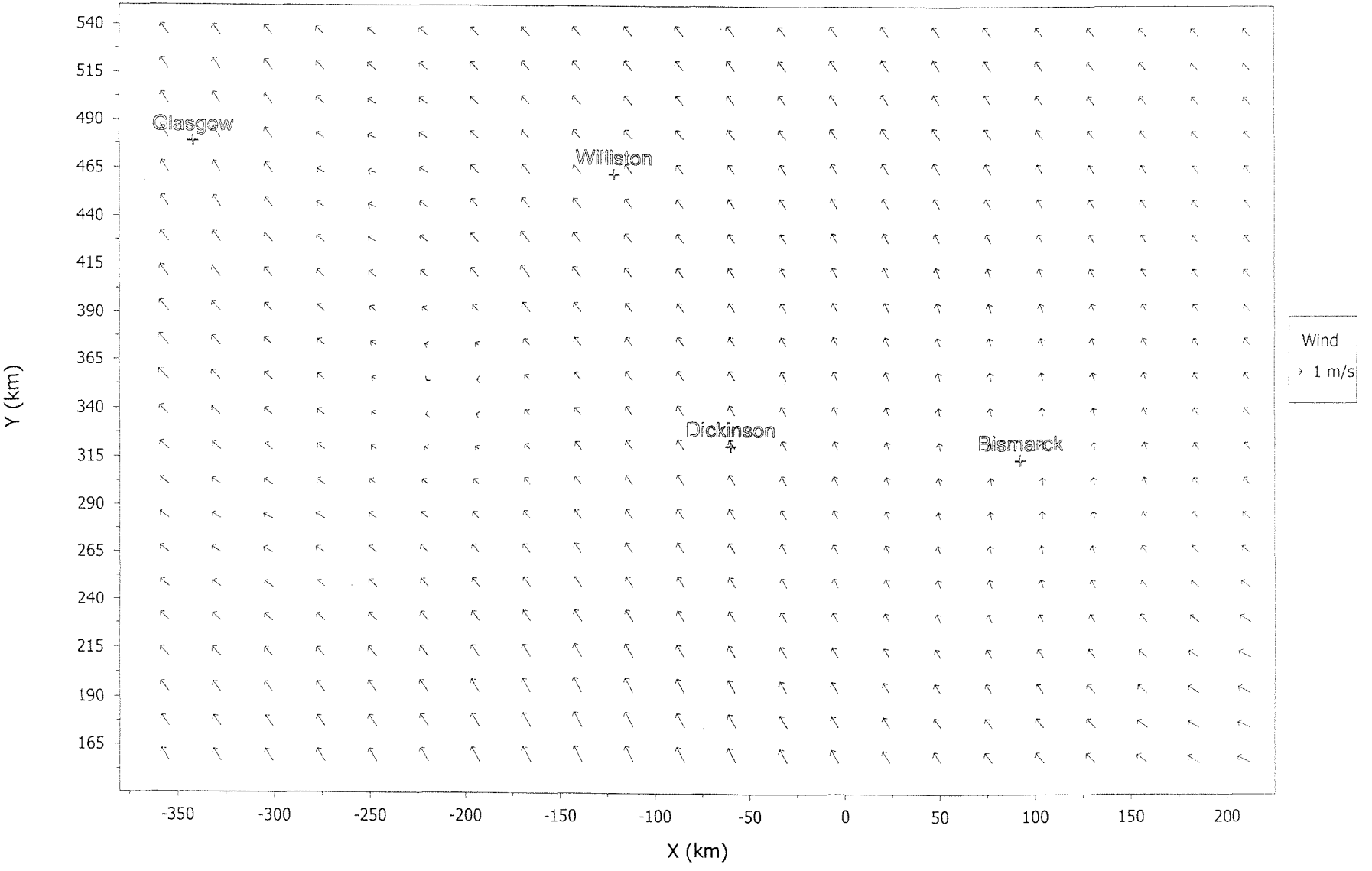


Exhibit 3
Average Wind Speed

January Episode (Sounding Hours Only)

| Layer 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| ENSR / Bismarck Observed | | | | | | | | | | |
| 2.044 | 1.775 | 1.577 | 1.452 | 1.331 | 1.228 | 1.207 | 1.149 | 1.179 | 1.242 | 1.159 |
| NDDH / Bismarck Observed | | | | | | | | | | |
| 1.001 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| ENSR / Glasgow Observed | | | | | | | | | | |
| 1.630 | 1.378 | 1.162 | 1.009 | 0.907 | 0.985 | 1.085 | 1.108 | 1.141 | 1.132 | 1.147 |
| NDDH / Glasgow Observed | | | | | | | | | | |
| 1.000 | 1.000 | 1.000 | 0.999 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Exhibit 4
Average Wind Speed

July Episode (Sounding Hours Only)

| Layer 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| ENSR / Bismarck Observed | | | | | | | | | | |
| 3.877 | 3.430 | 2.966 | 2.419 | 1.950 | 1.754 | 1.783 | 1.706 | 1.537 | 1.149 | 1.105 |
| NDDH / Bismarck Observed | | | | | | | | | | |
| 1.002 | 1.002 | 1.001 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| ENSR / Glasgow Observed | | | | | | | | | | |
| 2.151 | 1.937 | 1.631 | 1.382 | 1.196 | 1.246 | 1.297 | 1.271 | 1.180 | 0.978 | 0.981 |
| NDDH / Glasgow Observed | | | | | | | | | | |
| 1.000 | 1.000 | 0.999 | 0.999 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |